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Material Identification & Object Imaging

using . . .

Nuclear Resonance Fluorescence

Materials:
Explosives • Nuclear materials • Drugs • Chemicals • Toxic contraband

Containers:
Suitcases • Trucks • Oceangoing containers • Boxes of wood, iron, aluminum, etc.

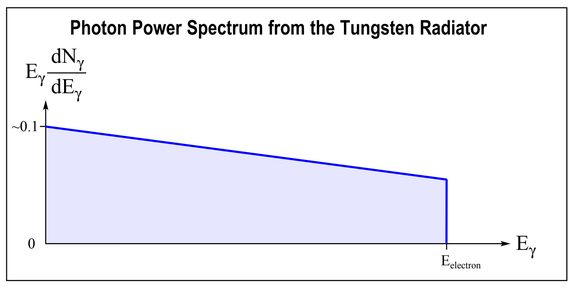
Advantages:
Very penetrating • Scalable for small and large objects • Unambiguous identification of atomic species and quantitative mass determination • Non-destructive

The Science

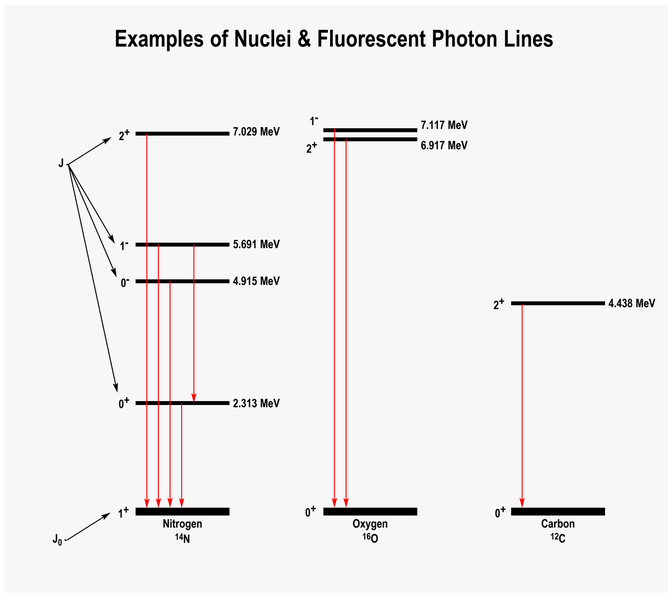
- Each nucleus has unique, characteristic excited states. These states are very narrow in energy, and rarely more than a fraction of an electron volt wide. They can be excited by the absorption of photons of the correct energy.
- When the excited state decays, the characteristic photons are radiated into all directions with respect to the incident beam, leading to unique photon energies of resonance fluorescence.
- The radiated photons can be detected by high-resolution solid-state Ge detector-spectrometers.
- Each nuclear species in the beam can be identified by the unique energy spectrum of the radiated photons.
- The probabilities or cross sections for resonantly absorbing photons are very large. However, penetration is very deep because of Doppler broadening from thermal motion.
- The angular distribution is a gentle function of angle, and depends on the angular momentum of the ground state, J_0, and of the excited state, J. Detector placement is not critical.
- Scattering by electrons backward of 90 degrees reduces photon energy below 0.5Mev. Thus, there is minimal background from Compton scattering.
- Photon beam is continuously distributed up to the electron energy (bremsstrahlung). Photons are available at all nuclear energies.
- The object is imaged by the collimated photon beam and the collimated view of the detectors.
- Selected scattering materials can be used to examine transmitted spectra for narrow line absorption. In this manner, the absorption of characteristic photon energies can be measured. This method of material detection is complementary to the detection of radiated photons.

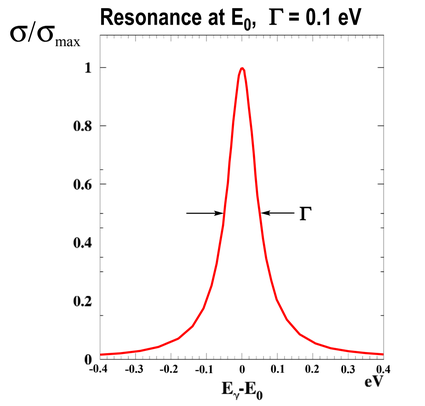
Realization

- Basic science is well established.
- System, hardware and software engineering required.
- Actively seeking resources for prototype development.



The techniques illustrated by this material are included in US Patents Numbers 5,420,905 and 5,115,459





$$\sigma = \frac{\lambda^2 \Gamma^2 G}{4\pi [(E_\gamma - E_0)^2 + (\Gamma/2)^2]}$$

$$G = \frac{2J+1}{2J_0+1} \qquad \lambda = \text{photon wavelength}$$

$\sigma_{max} \sim$ 500 barns (10^{-24} cm^2)
$\Gamma \sim$ 0.1 eV
} Doppler broadening => Thermal motion {
$\sigma_{max} \sim$ 3 barns
$\Gamma \sim$ 20 eV